Functional ecology in the SBG Era:
An assessment of the state of plant trait retrieval from imaging spectroscopy

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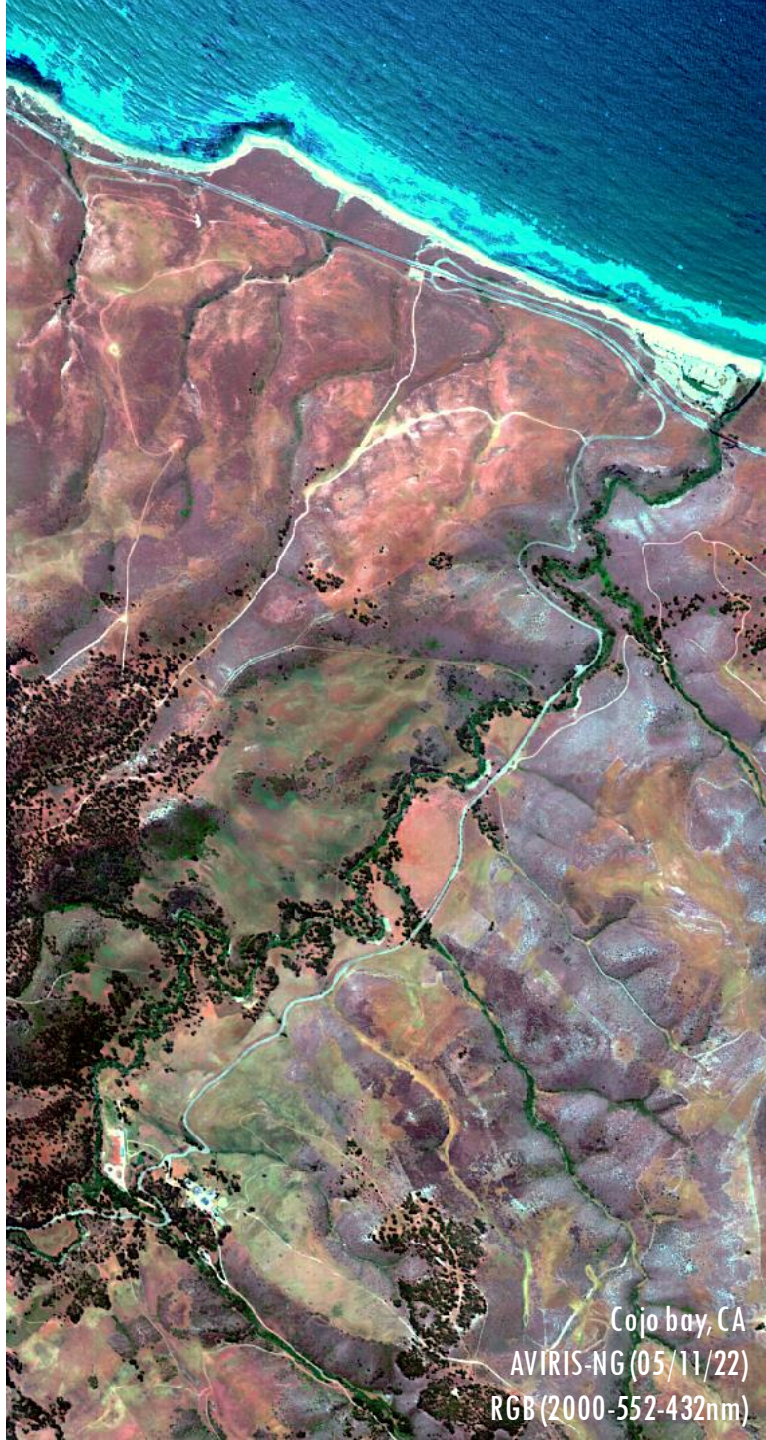
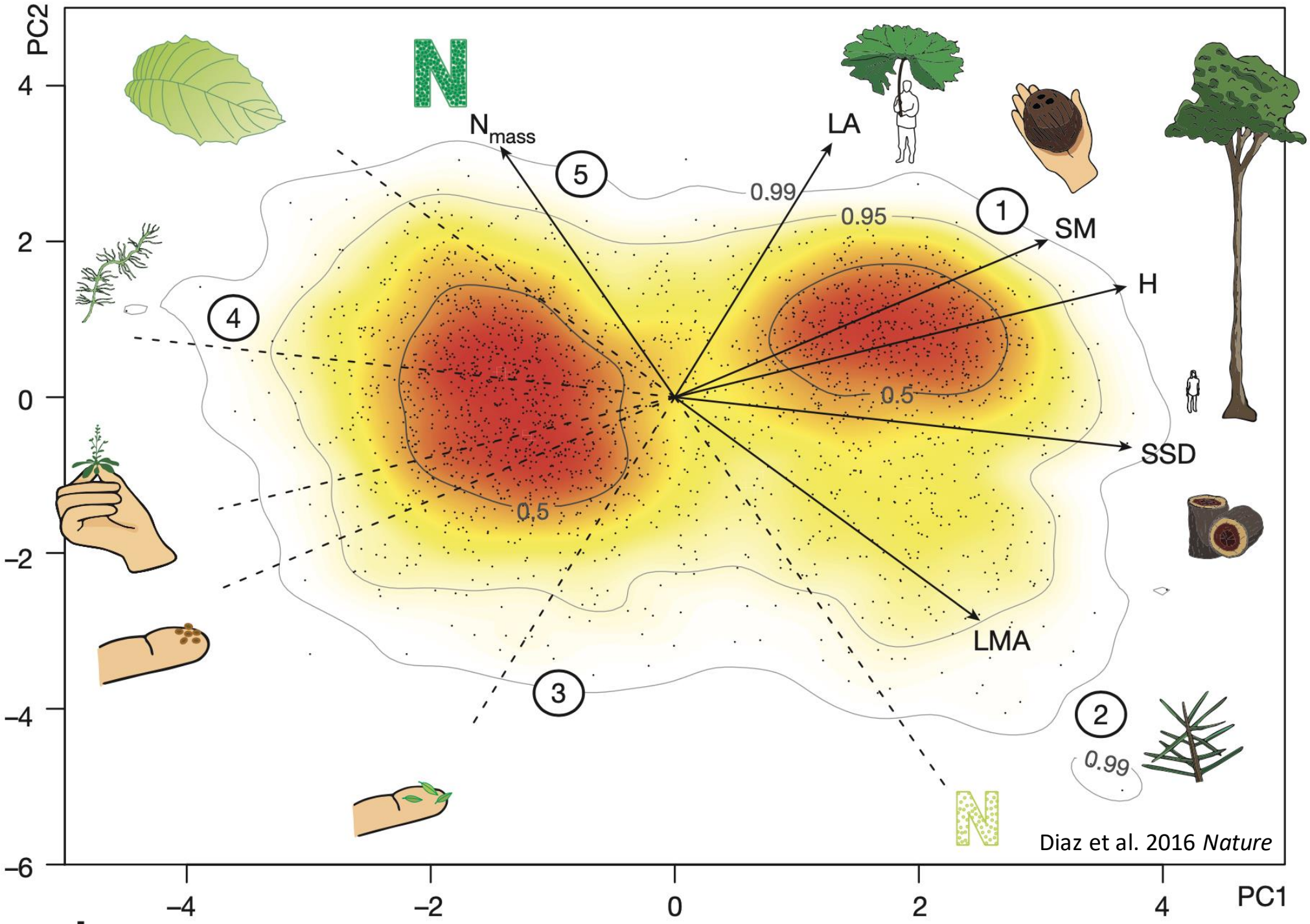


Supported by the NASA ROSES 2020 New (Early Career) Investigator Program in Earth Sciences.

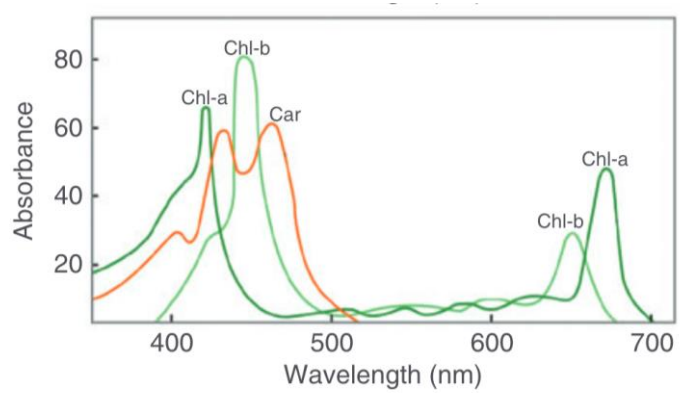
Plant functional traits

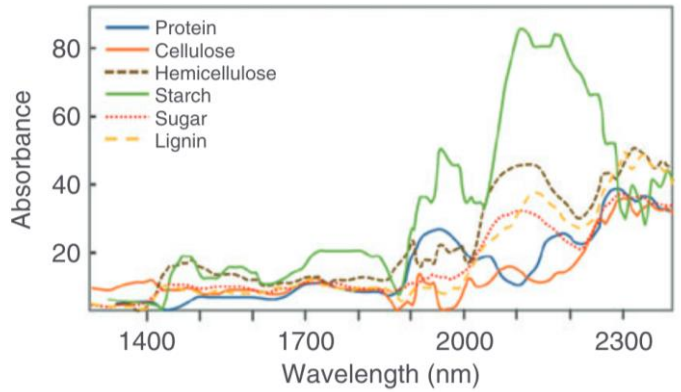
Measurable characteristics of plants that are closely related to function and fitness.

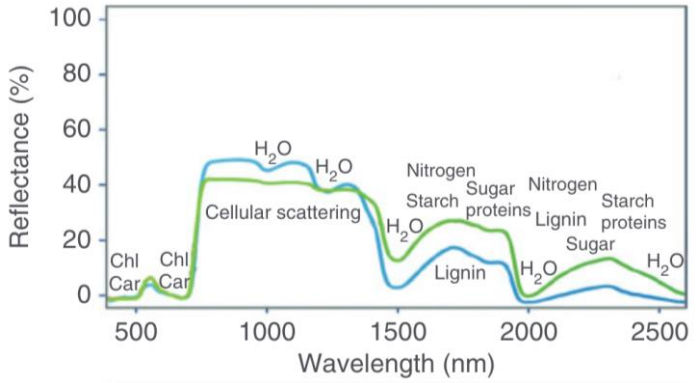


Diaz et al. 2016 *Nature*

Leaf traits affect leaf reflectance…

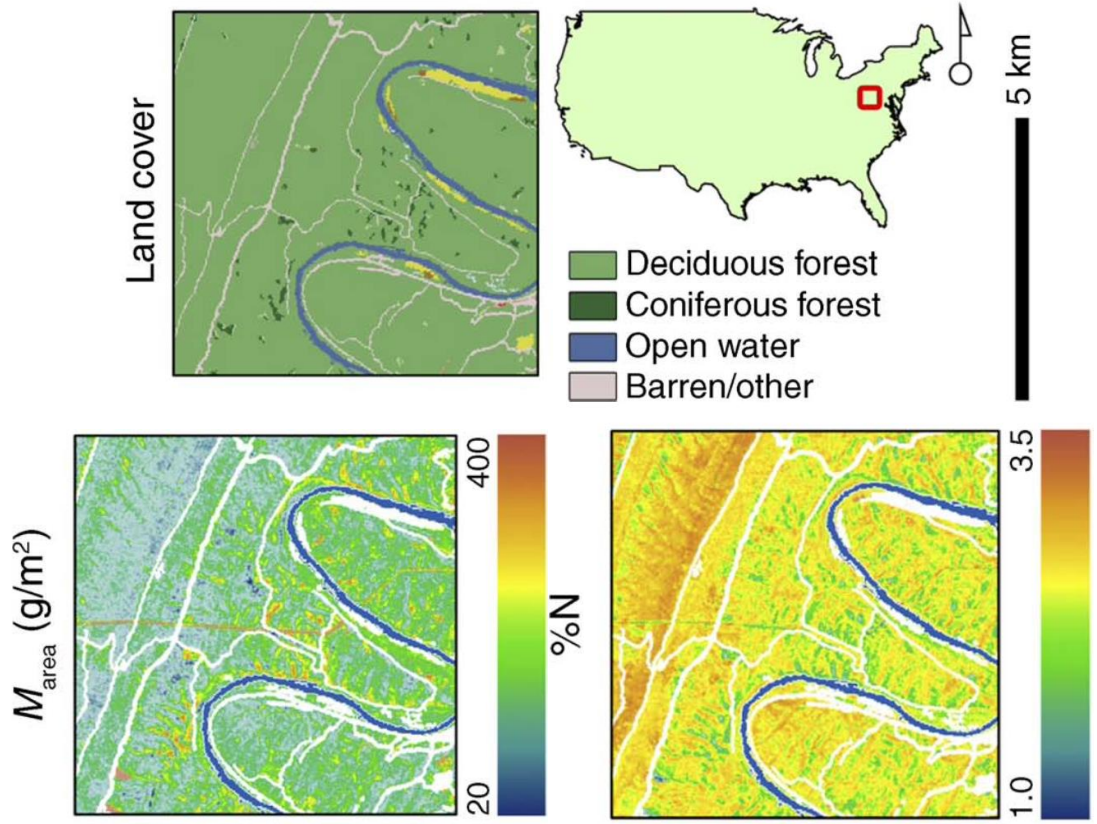






Trait retrieval algorithm

…allowing us to estimate leaf traits from remote reflectance measurements

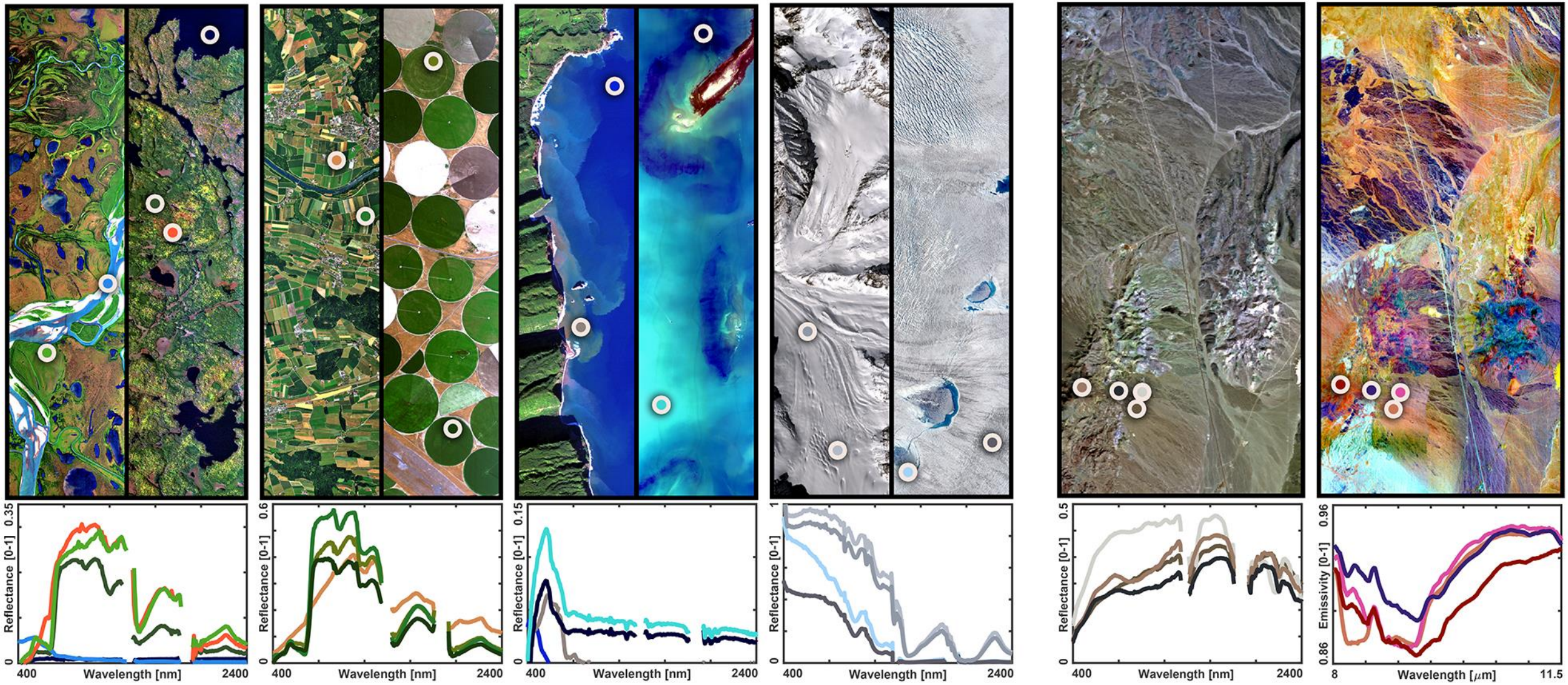


Singh et al. 2015 *Ecological Applications*

SBG provides data for many focus areas ...

... and will see the world in two critical spectral regions

Ecosystems | Agriculture | Coastal Zones | Snow and Ice | VSWIR | Minerals | TIR



SBG will be one of the first satellites to acquire regular, global imaging spectroscopy data

Schneider et al. 2019 *Eos*

~~(1) What are the "best" algorithms, at both leaf and canopy scales?~~

"Boring! Make new algorithms!"
- NASA review panel

OK.
- Shiklomanov et al.

(2) Why do these algorithms succeed (or fail), and under what conditions?

~~(3) How should we measure spectra to get the best trait estimates?~~

"Too late -- nobody cares!"
- NASA review panel

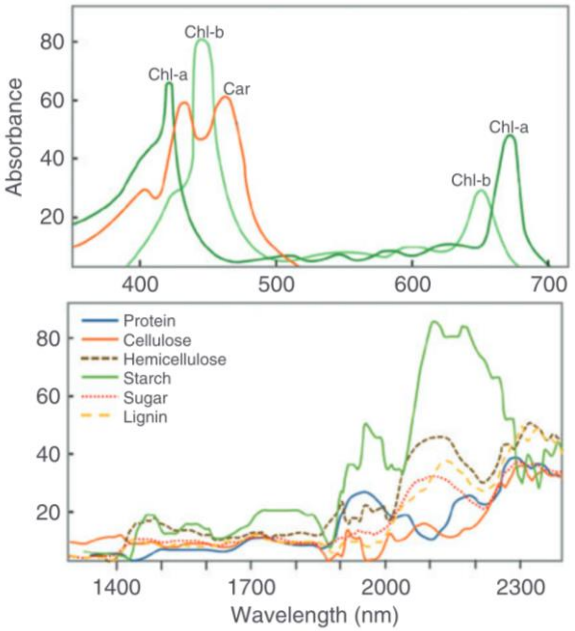
Fine, we'll look at flowers instead!
- Shiklomanov et al.

(2) Why do these algorithms succeed (or fail), and under what conditions?

"Visible"
Clear physical basis

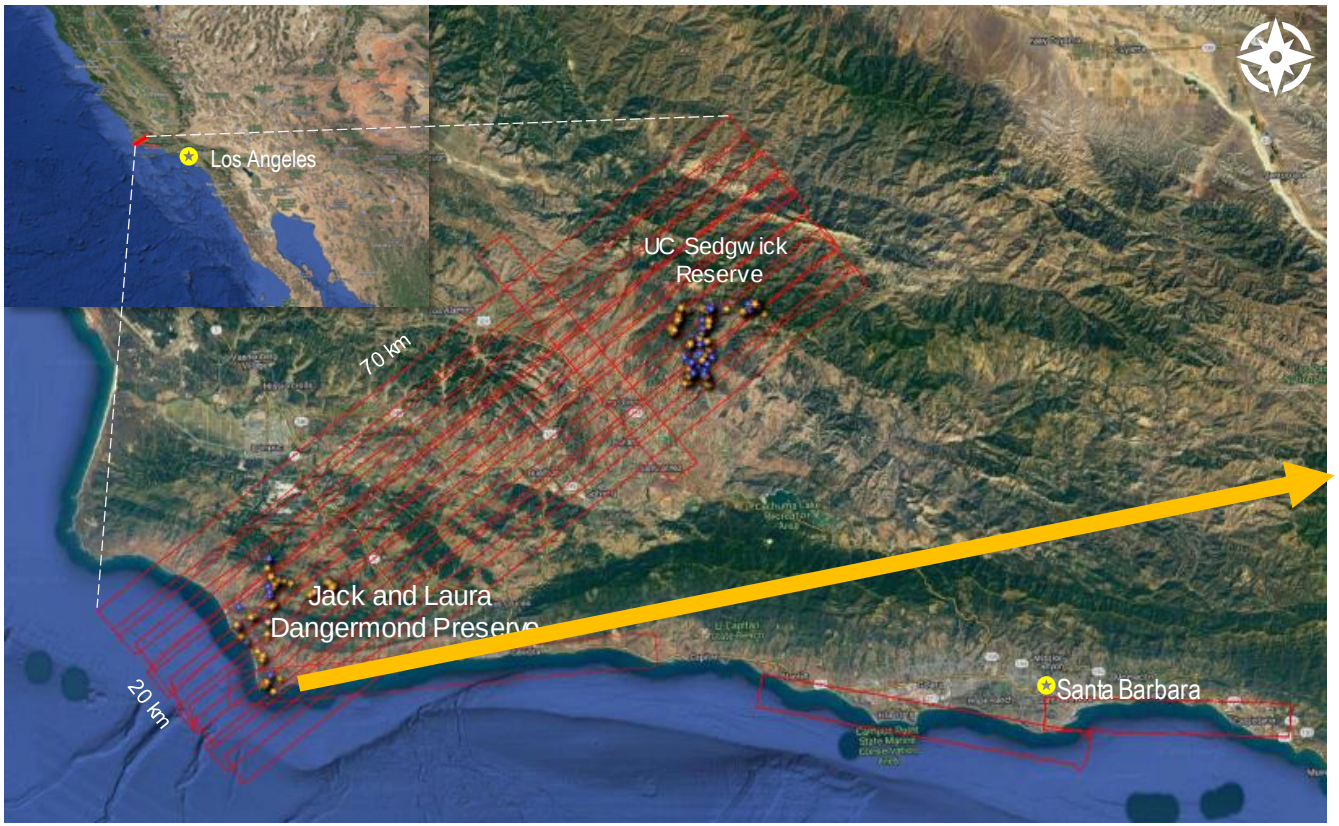
"Invisible"
No direct physical basis

Water
Chlorophyll
Cellulose
Protein
Starch
Phenols
LMA
%N
%C
Mg
Ca
P
K
B
Fe
Vcmax
Jmax
∂13C



***Why* is it possible to map "invisible" traits? What are we *really* seeing** when we see "invisible" traits, in terms of correlations with other traits, structure, etc.? **Can we leverage these correlations to make better algorithms?**

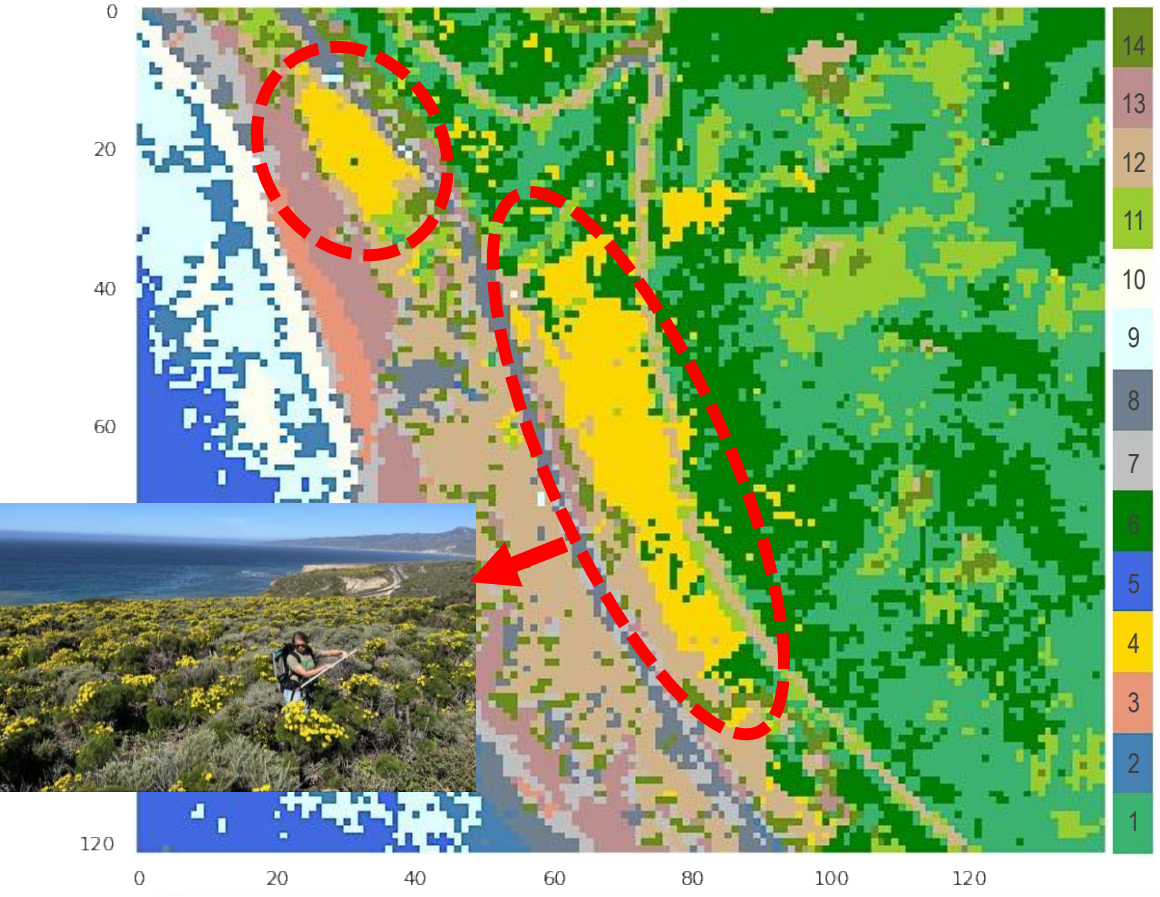
(3) Flowers!



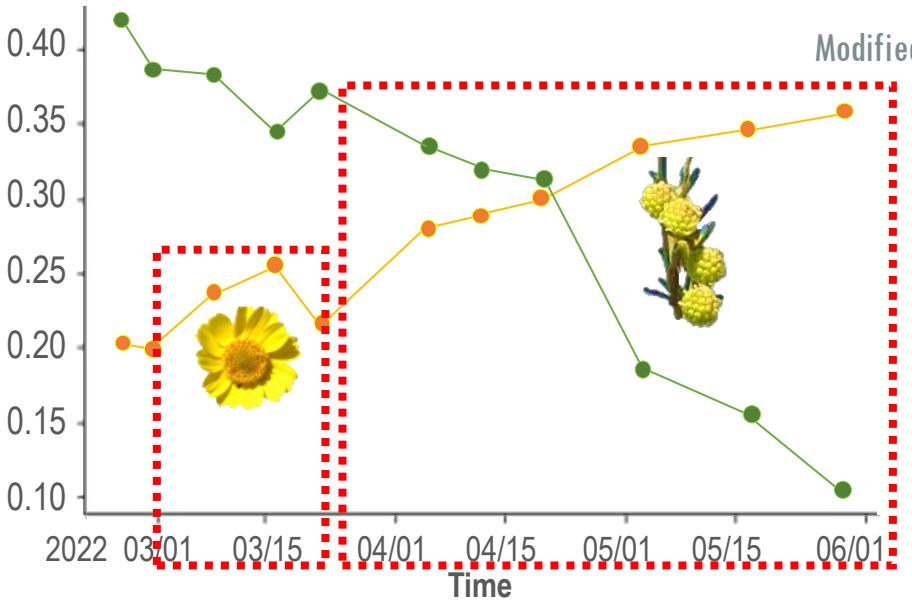
SBG High-Frequency Time series (SHIFT) — Weekly AVIRIS-NG flights during spring/summer 2021, with coordinated field sampling.

Dr. Yoseline Angel

Mapping flowering areas and studying flower phenology



Pixels classified as flowers are yellow. Other classes include ocean/dark (blue, white), soil (earth tones), and vegetation (greens).



Modified enhanced blooming index (MEBI)
(Adapted Chen et al., 2019)

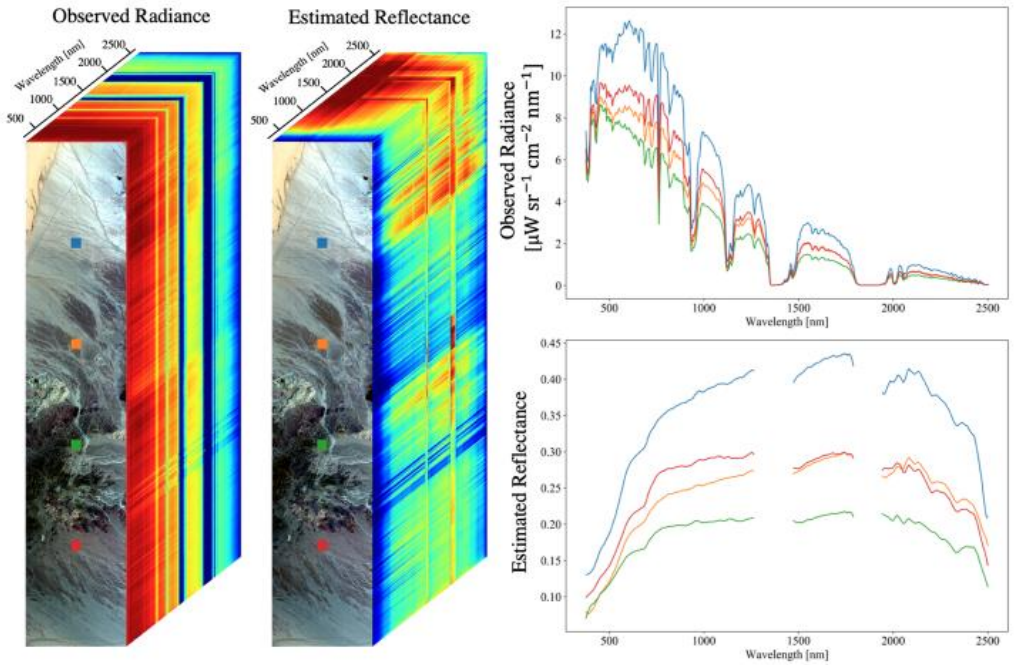
Red-edge normalized difference vegetation index (RENDVI)
(Gitelson & Merzlyak, 1994)

New vegetation index for yellow flowers shows **different temporal pattern than green vegetation index**, and highlights two distinct flowering cycles corresponding to two different species.

Dr. Yoseline Angel

Facilitating imaging spectroscopy data analysis with cloud computing

SHIFT airborne data are **huge** (300 GB per flight line; 5.4 TB total) and **complex** (high-dimensional, multi-file formats, multiple processing levels)



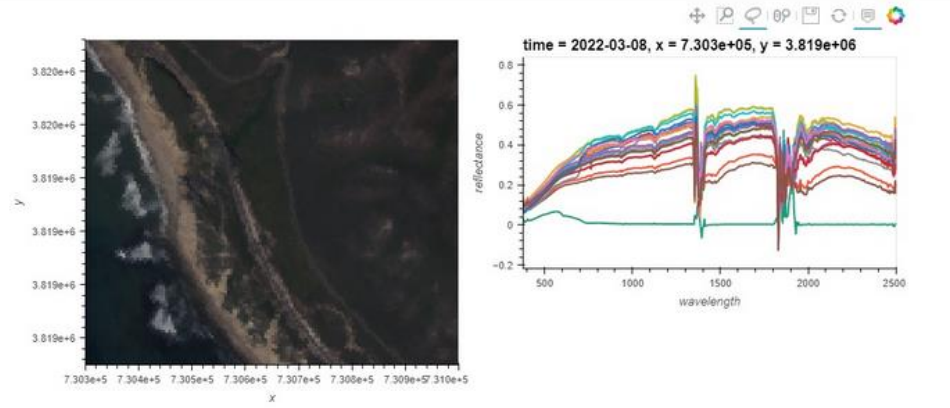
https://shift-smce-user-guide.readthedocs.io

Evan Lang

SHIFT project on NASA Science Managed Cloud Environment (SMCE) provides cloud-based interactive analysis capabilities (JupyterLab), scalable compute (SLURM) next to the SHIFT airborne data, and tools and documentation to make all of this easier!

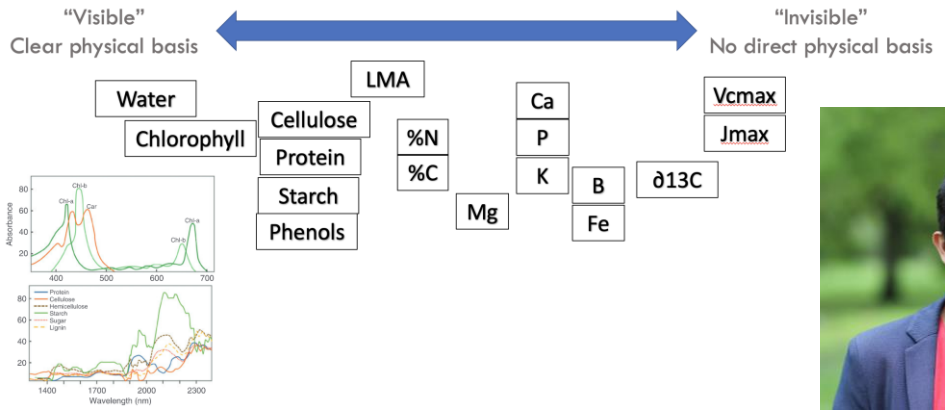
Spectra Selection

```
# Create the RGB image plot
rgb_image = ds_rgb.hvplot.rgb(
    x='x', y='y', bands='wavelength', aspect = 'equal', frame_width=400).opts(
    tools=["hover", 'lasso_select'])

# Create streams
posxy = hv.streams.PointerXY(source=rgb_image, x=730302.5, y=-3819657.5)
sel = hv.streams.Lasso(source=rgb_image, geometry=np.array([[730302.5, 3819657.5]]))

# Function to build a new spectral plot based on mouse hover positional
# Information retrieved from the RGB image using our full reflectance dataset
def point_spectra(x,y):
    return aoi.sel(x=x,y=y,method='nearest').hvplot.line(
        y='reflectance',x='wavelength', color='#1b9e77', frame_width=400)

def selected_info(geometry):
    x = find_nearest(aoi.x, geometry[:, 0])
    y = find_nearest(aoi.y, geometry[:, 1])
    points = set(list(zip(x, y)))

    list_of_lines = [aoi.sel(x=x, y=y, method='nearest').hvplot.line(
        y='reflectance',x='wavelength', frame_width=400) for x, y in points]
    return hv.Overlay(list_of_lines)

# Define the Dynamic Maps
point_dmap = hv.DynamicMap(point_spectra, streams=[posxy])
lasso_dmap = hv.DynamicMap(selected_info, streams=[sel])

# Plot the RGB image and Dynamic Maps side by side
(rgb_image + point_dmap*lasso_dmap)
```



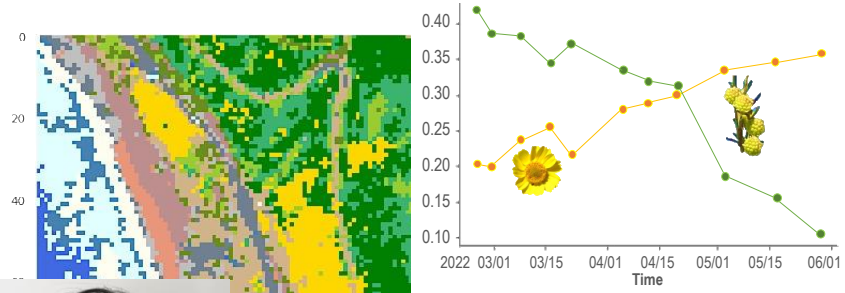
Tell me more!

New retrieval algorithms:
Dhruva's poster



Dr. Dhruva Kathuria

Flowers:
Yoseline's poster



Dr. Yoseline Angel

Cloud computing tools:
https://shift-smce-user-guide.readthedocs.io

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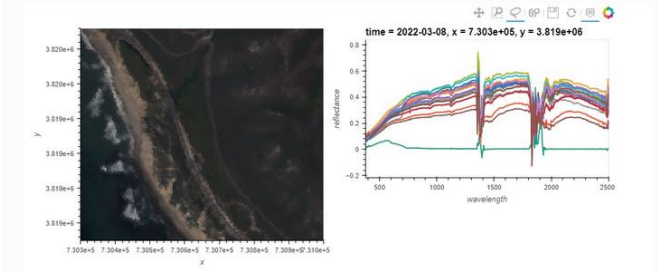

Evan Lang

…and see the 15-minute version of this talk at the Terrestrial Ecology meeting, Tuesday, 9:55am, Terrapin Ballroom